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PATENT SPECIFICATION

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(54) A REVERSIBLE FLOW VALVE FOR GROUND DRILLING COLUMNS

(71) We, TURBODRILL INTERNATIONAL CORPORATION, a body corporate organized under the laws of the Dutchy of Liechtenstein, of P.O. Box 23 548, Schaan, Liechtenstein, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates generally to devices or installations for drilling the ground.

Every carefuly devised drilling program must permit at any required time so-called "lost circulation" or "clogging" products to be injected into the drilled hole, said products being constituted by substances such as ground nut shells, fibrous materials of every description, plastic sheets, etc. Now some modern tools for working up the bottom of the borehole or well such as high pressure drilling bits, underground motors such for example as drilling turbines or the like unduly restrict the flow of such products or become clogged up, thus stopping the flow of the fluid.

Valves incorporated into tubular columns particularly casings are already existing, which normally allow the axial flow of the circulating fluid, while diverting the stream of fluid towards the annulus about the column when they are tripped into operation by introducing into the column a device such as a ball or a loading or ballasting bar having a suitable seat. Such valves often comprise an annular jacket normally held in a position for closing side ports by shearing pins or similar means and having a seat for the application of the ball or loading bar which closes off the axial passage of the valve. Due to the effect of overpressure which results from this above the ball or bar, said pins are shorn off and the jacket comes to a position which uncovers the side ports. Obviously the device thus provided operates irreversibly and the side ports remain open at the end of the operation.

The object of the invention is to remedy the disadvantage which may result from the irreversible character of this operation and to provide an improved flow valve so actuatable as to ensure flow of the circulating fluid through side ports but returnable to its initial position following said operation, for example at the end of the injection of the products for resuming a normal flow.

Another object of the invention is to provide a reversible flow valve actuatable by a loading bar or a similar device which falls down the well but is returned to its position reestablishing a normal flow when said bar or device is fished up.

According to the invention a reversible flow valve for a tubular ground drilling column is provided, said valve being arranged to be located over a part of the column, such as a drilling bit or underground drilling motor, to be protected against clogging, said valve comprising a body having side ports, an annular jacket slidable in sealed fashion in said body between a port-closing position and a port-releasing position while defining an axial channel, a seat arranged in the upper portion of said jacket for intercepting a closing member for said axial channel such as a loading bar, a gasket fitted upon said jacket and an associated seat on said body or on an element connected thereto to prevent passage of fluid through said side ports in the body, the gasket and associated seat being so arranged that fluid tightness is ensured between the inner and outer diameters of said jacket by pressure on said jacket resulting from a higher pressure prevailing inside the valve and a lower pressure prevailing outside the valve.

Due to the fact that the pressure prevailing inside the column in which the valve is interposed is higher than the outer pressure which prevails in the annulus of the well and that said inner pressure is exerted over the entire cross sectional area of the annular jacket from the underface of this jacket but only over a portion of its cross section from the upper end while the remainder of said cross section is subjected to the effect of a smaller outer pressure, the jacket has a tendency to be held against the associated

seat by the differential pressure resulting from the difference between the inner and outer pressure. The force as applied is larger as the difference between the two pressures is higher.

According to an advantageous constructional form, there is provided on the valve body an annular wear part, for example near or above the seat formed on said body and the loading member has such an outline as to define with said wear part, when it rests upon the seat on the annular jacket, an annular throttled portion creating such a pressure loss that the pressure exerted upon said loading member performs a complete opening of the valve and retains it in opened position during the injection. The fluid is thereby prevented from flowing under throttled condition between the valve seat and the gasket as normally takes place in those valves which become opened due to a pressure difference between their two opposite faces and eliminates dangers arising therefrom, particularly when using an abrasive liquid. According to the invention, the pressure loss which is necessary for opening the valve is thus generated by a device which is independent of the valve itself and results in the present case from the throttling action exerted on the injection fluid between the wear part and the loading member.

According to another feature, the annular jacket is provided adjacent its lower end with a skirt or like part defining with the valve body a chamber accommodating a spring which is fulcrumed on a part which may provide with said skirt a small clearance so as to exert on the fluid which tends to escape from said chamber a throttling action amounting to a braking effect on the jacket motion when the valve has a tendency to be suddenly opened, such a braking effect adding itself to the resistance as exerted by the spring.

The following description which reads on the accompanying non-limitative drawing will facilitate the understanding of the invention.

Figure 1 is a vertical sectional view of a flow valve according to the invention shown in drilling position.

Figure 2 is a cross sectional view on the line II-II of Fig. 1.

Figure 3 is an elevational view of a loading bar utilizable for controlling the valve shown in Fig. 1.

Figure 4 is a vertical sectional view of the valve shown in opened position.

The valve shown in the drawing comprises a hollow body 1 provided at its ends with threaded portions 2 for connection in a drilling column (not shown) and having side ports 3 for the outflow of the product-laden fluid towards the annulus of the borehole, said ports being interconnected by an annular channel 3'. The body 1 is provided adjacent its upper end, over the ports 3, with an inner threaded portion 4 in which is screwed a seat 5 having a surface 6 for engagement by an associated gasket as described hereafter and provided with an inwardly directed wear surface 7. The seat 5 has inner notches 8 permitting it to be screwed up to into the threaded portion 4 and is surmounted by a nut 9 also having notches 10 for screwing up purposes and associated with a locking device 11.

An annular jacket 12 defining an axial passage 13 is slidably housed in the body 1, fluid tightness between these elements being ensured by axial gaskets 14. This jacket 12 has a seat 15 the purpose of which will be indicated hereafter and a recess 16 in which is received the gasket 17 which cooperates with the surface 6 of the seat 5.

The jacket 12 extends downwardly in the form of a skirt 18 defining between it and the body wall a chamber 19 housing a return spring 20 the end of which is abutted against a shoulder on the jacket adjacent the top of the skirt 18 and at the other end against a base part 21 screwed into a threaded portion 22 of the body. Such a base part 21 is held in place by means of a resilient ring 23 and has inner screwing notches 24 and it carries an upwardly directed trumpet part 25. The skirt 18 and the trumpet part 25 connected to the base part 21 have matching flaring portions thereby providing a clearance 26 through which the fluid is throttled (as shown in Fig. 4) for inhibiting any sudden motion of the jacket. In Fig. 3 is shown a loading or ballasting bar comprising a body 28 surmounted by a fishing up head 29 and downwardly extending in the form of a guiding rod 30 which tapers at its end and has guiding ribs 31 which centralize the bar in the bore 13 of the jacket 12. The bar body is provided adjacent its lower end with a resilient gasket 32 adapted to cooperate with the seat 15 of the jacket 12.

The operaton of the flow valve as described when incorporated in a tubular ground drilling column is as follows:

In Fig. 1 is shown the inoperative position of the valve i.e. the position assumed by the several elements when the flowing drilling fluid can freely pass through the bore 13 to reach for example a drilling tool or an underground drilling motor. Assuming that under the prevailing conditions there is a pressure P_1 inside the valve owing to fluid flow and a pressure P_2 which is smaller than P_1 outside the valve in the annulus about the column, the gasket 17 on the jacket 12 engages the surface 6 of the seat 5 for ensuring tightness due to the differential pressure resulting from the sectional differences on which the pressures P_1 and P_2 are operative in both up and down directions.

Leaving aside as negligible the pressure drop through the channel or bore 13, it is found that the jacket undergoes the effect of a downwardly directed thrust as exerted by the pressure P over a cross section which is defined internally by the radius R_4 of the bore 13 and externally, depending upon the degree of tightness between the gasket 17 and the seat 6, by a radius R′ which is such that

$$R_1 \leqq R' < R_2$$

where R_1 is the inner radius of the part 5 and R_2 is the outer radius of the gasket 17. Such downwardly directed thrust is increased by the thrust exerted by the pressure P_2 on the surface defined by radii R′ and R_3, the last-cited radius designating the outer radius of the jacket 12.

The total downwardly directed thrust is therefore equal to:

$$F_1 = \pi (R'^2 - R_4^2). P_1 + \pi (R_3^2 - R'^2). P_2$$

Conversely, the jacket 12 is applied against surface 6 by the action of pressure P_1 over a surface defined by radii R_4 and R_3. Moreover such pressure is increased by the force exerted by the spring 20 and designated here by f. Consequently the total thrust is equal to:

$$F_2 = \pi (R_3^2 - R_4^2). P_1 + f$$

Leaving aside the force f of the spring and the weight of the jacket and assuming that R′ approaches the limit R_2, the resultant pressure which urges the jacket 12 against its seat can be easily calculated. The value of such a pressure is as follows:

$$F = F_2 - F_1 > \pi (R_3^2 - R_2^2). (P_1 - P_2)$$

Assuming by way of example that $P_1 - P_2 = 50$ kilograms per sq. centimeter that $R_3 = 65$ millimetres and $R_2 = 55$ millimeters, the following ratio can be written

$$F > 1860 \text{ kilograms}$$

For $R'_{max} = R_1 = 46$ millimeters the following unequality then prevails

$$1860 < F < 3300 \text{ (kilograms)}$$

which is amply sufficient for ensuring tightness between the gasket 17 and the seat.

A radius R_3 substantially larger than radii R_1 and R_2 is so selected as to obtain a larger thrust surface in the zone of application of the gasket upon its seat.

When the loading bar is introduced into the tubular column (generally owing to a free fall) said bar closes the bore 13 while assuming the position shown in Fig. 4. Pressure under the valve then becomes equal or approximately equal to P_2 and the entire overpressure P_3 exerted by the pumps is operative upon the surface defined by the radius R_1. Consequently the jacket 12 is moved off the seat 5 by a force F_3

$$F_3 \geqq \pi R_1^2 (P_3 - P_2)$$

which in the present case amounts up to

$$F_3 \geqq 66 (P_3 - P_2).$$

As soon as said thrust exceeds the force f of the spring, the jacket 42 is moved downwardly while opening the passage toward the side ports 3. It will be seen from Fig. 4 that as such an opening action takes place, throttling is created at 33 between the body 28 of the ballasting bar and the wear part 7. A pressure drop follows which is so calculated that the resultant thrust is sufficient for fully opening the valve and holding the jacket in opened positions during the injection of the products. Owing to this, the flow speed of the fluid between the gasket 17 and the seat 5 is negligible and every risk of an abrasion is avoided.

Should there be too violent a rise of the pressure P_3 which would have a tendency suddenly to shift the jacket 12, motion of said jacket is hindered by the throttling action exerted on the fluid through the gap 26 between the skirt portion 18 and the trumpet portion 25.

When the injection is completed, the loading bar is retrieved and the valve resumes its drilling position. The conicity angles of the body 28 of the loading bar and rod 30 are so calculated as to avoid any wedging action.

Modifications can be introduced to this constructional form in the field of technical equivalencies without departing from the ambit of the invention as defined in the appended claims. Thus where it is feared that clogging materials may choke up the throttled portion 33, the spring 20 may be so calculated as to permit the ballasting bar to effect an additional downward motion beyond the position shown on Fig. 4 for opening up said throttled portion.

A variation of such a safety device consists in so arranging the upper portion of the body 28 of the loading bar that it may slide therealong and in holding the same in position by means of elastic devices the compression of which widens or frees the

throttling gap 33 when the injection pressure increases beyond a given limit owing to part or full obstruction of the gap 33.

WHAT WE CLAIM IS:—

1. A reversible flow valve for a tubular ground drilling column arranged to be located over a part of the column such as a drilling bit or an underground drilling motor, to be protected against clogging, the valve comprising a body having side ports, an annular jacket slidable in sealed fashion in said body between a port-closing position and a port-releasing position while defining an axial channel, a seat arranged in the upper portion of said jacket for intercepting a closing member for said axial passage such as a loading bar, a gasket fitted upon the jacket and an associated seat on the valve body or an element connected to it to prevent passage of fluid through said side ports in the valve body, said gasket and the associated seat being so arranged that fluid tightness is ensured between the inner and outer diameters of said jacket by pressure on said jacket resulting from a higher pressure prevailing inside the valve and a lower pressure prevailing outside the valve.

2. A flow valve according to claim 1 in combination with a closing device or loading bar, characterized by the fact that there is provided on the valve body an annular wear part, for example adjacent the seat on the valve body or thereabove and furthermore by the fact that the closing device or loading bar has such an outline as to define with said wear part when it rests upon the jacket seat, an annular throttled passage generating such a pressure drop that the thrust exerted upon said closing device fully opens the valve and holds it in opened position.

3. A flow valve according to claim 2, wherein the closing device or the loading bar is provided with a head for fishing purposes.

4. A flow valve according to any one of the preceding claims wherein gaskets are interposed between the jacket and the valve body.

5. A flow valve according to any one of the preceding claims wherein the annular jacket defines with the valve body a chamber in which is housed a spring or equivalent resilient member which urges the valve upon its associated seat.

6. A flow valve according to claim 5 wherein the spring-housed chamber is separated from the axial passage in the jacket by a throttled portion which reduces the flow rate while to slow the jacket motion.

7. A flow valve according to claim 6 wherein said throttled portion is provided between a portion of the jacket, for example a skirt portion, and a part secured to the valve body, for example in the shape of a trumpet fitted in telescoping relation with the jacket skirt.

8. A flow valve according to claim 1 wherein the jacket is formed at its upper end with a recess in which is arranged the gasket associated with the seat on the valve body, the circular boundaries of said gasket being spaced from the surfaces corresponding with the inner and outer radii of the jacket.

9. A flow valve according to claim 2 wherein the annular throttled passage which produces the pressure drop causing the valve to become opened becomes wider if a closing or clogging action takes place owing to an axial motion of the closing device or loading bar due to overpressure following said clogging action which exerts an additional compression on an elastic device which axially holds the jacket gasket against its associated seat.

10. A reversible flow valve particularly for drilling outfits or installations substantially as hereinbefore described and shown in the accompanying drawings.

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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

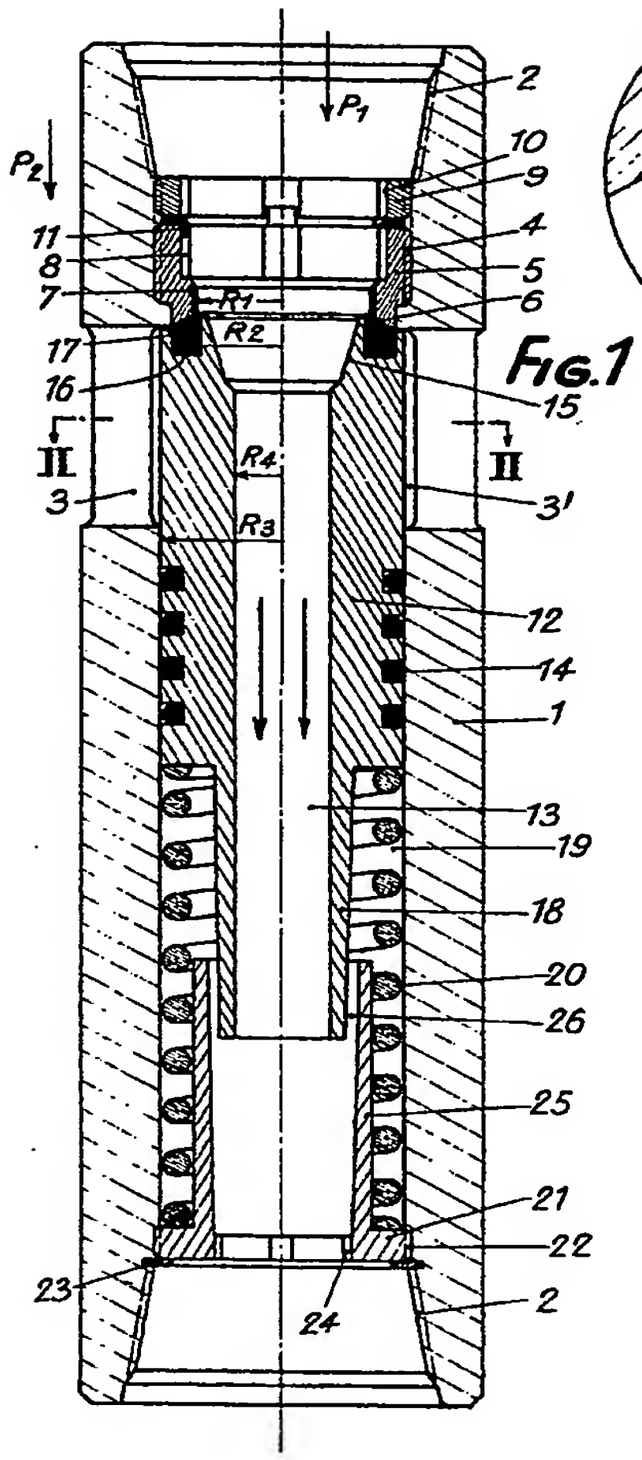

FIG. 1

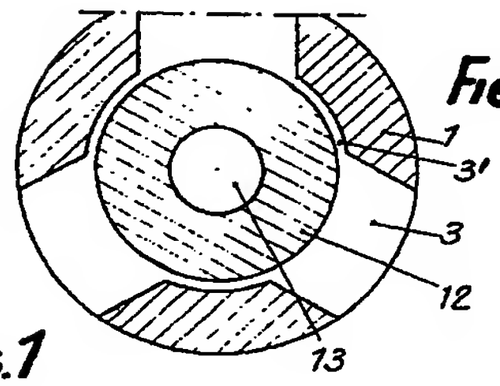

FIG. 2

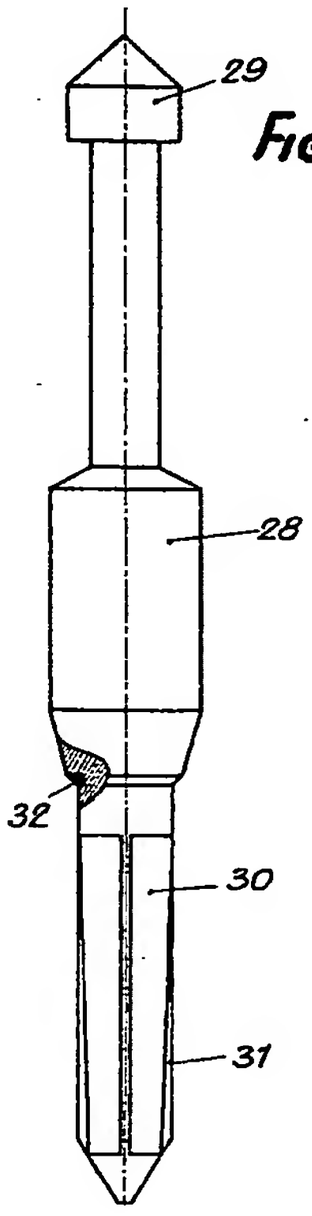

FIG. 3

1295373 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

FIG. 4